Economics *of* biodiversity vs. economics *for* biodiversity: valuation of harmful drivers in the Amur Tiger case (Jilin, China)

EXECUTIVE SUMMARY

Joshua Berger, intern at Ecowhat
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This executive summary is aimed at **(1)** environmental NGOs, **(2)** decision-makers facing environmental dilemmas and **(3)** researchers conducting field work to characterize economic activities threatening biodiversity. A shorter three-page executive summary is available for the first two groups. Taking inspiration in the shorter version, this longer version also seeks to provide insights on how to employ economic tools to analyse an environmental issue and how to resolve this problem. In particular, it uses the example of Amur tiger conservation and outline how to design *relevant* and *efficient* economic incentives (such as subsidies or community programs that support households to engage in a new activity) with the goal of tackling environmental issues. It extends the shorter executive summary by describing how to study the economic threats to biodiversity and which tools to employ.

Analysis framework

Our analysis is centred on an environmental issue and seeks to resolve it. Accordingly, the results of the analysis are explicitly aimed at people who protect the environment. Our work falls within the *strategic environmental management analysis* (SEMA) approach (Mermet 2011) which places a focus on the **conflicts** and **strategic aspects** of environmental issues. The SEMA approach rejects the idea that collaboration alone can motivate the major changes in resource exploitation needed to solve major environmental issues. If stakeholders presented, currently present and will present divergent interests, then gathering them together around a table will neither trigger the disappearance of their opposition nor solve the issue at stake. Actions for change must instead be carried out by minority actors who oppose the economic sectors that currently threaten the environment. The framework offered by SEMA seeks to shed light on the conflicting interests and actions while at the same time providing an environmentally-favourable analysis. It distinguishes *actual management* which corresponds to the actions that affect the environment, even if they do not intend to, and *intentional management* which corresponds to actions undertaken with the fate of the environment in mind. SEMA also classifies stakeholders according to their role: those minority actors that lead the struggle to protect the environment are referred as *strategic environmental actors*, those who belong to the activity sectors that threaten biodiversity are referred as *sector-based actors*, and those who belong to "*a rule-based or rule-making mediation or authority*" (Mermet 2011) that entrenches the established balance of power between the two previous actors are referred as *regulating actors*.

As a graduating Master of Science student, I led a case study and studied the organized groups and divergent interests that surround Amur tiger (*Panthera tigris ssp. altaica*) conservation That study was financed by the Fondation d'entreprise Hermès and coordinated by Ecowhat and the International Institute of Sustainable Development and International Relations (Iddri, France). It was conducted during the summer 2011 in Hunchun, in Jilin province, China. In order to define whether economic activities are detrimental or favourable to tigers, we were required to explicitly define what we considered as the conservation objective:

A self-sustainable population of Amur Tigers reconquering its original historic range, i.e. ranging from Russia Far East to North Korea in the south and Mongolia in the west[1].

This long-term objective (referred to as the *reference objective*) was chosen because of its ethical foundation (human actions caused the retreat of Amur tigers out of their original range) and its operational and strategic values. Most environmental actors we met indeed have this *reference*

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[1] (Miquelle et al. 2010)

objective in mind (Miquelle et al. 2001). Therefore an analysis that outlines how to reach this objective will be valuable to them.

Another reference objective would certainly bring different results. In effect, the objective determines the way economic activities are considered by the analyst. The same activity can both foster the reproduction of tigers, thus supporting their recovery, and at the same time represent a threat for the diversity of tree species in the forest. With the above-mentioned objective in mind, the analyst would advice the promotion of this activity and oppose it if the *reference objective* was to increase the diversity of trees.

Economic activities can be classified into three main categories relative to the *reference objective*: *synergistic*, *incompatible* or *compatible.* They respectively go in the same direction as the objective (i.e. increase tigers' populations and habitats), in the opposite direction or do not affect the objective. With our *reference objective*, corridors to let tigers expand to new territories are needed and as a consequence some areas that grow crops are *incompatible.* If we aimed only at the conservation of current habitat, the same corridors would be *compatible*.

Case study area

Hunchun city, in north east China, belongs to Jilin, one of the two provinces in China where Amur tigers are present. They are protected internationally and are IUCN red listed. Amur tiger trade was banned in China in 1993. Hunting of any species and the use of guns are prohibited in Jilin (Miquelle et al. 2001). Hunchun Natural Reserve was established in 2001 and subsequently upgraded to the National status in 2005. It would host between 3 and 7 tigers (B. Li et al. 2009), out the 16-22 tigers that are supposed to live in China (Miquelle et al. 2010). Human activities are in theory prohibited inside its core zone but local authorities tolerate some of them on the argument that the practise of these activities predated the establishment of the Nature Reserve (e.g. it is illegal but considered “reasonable” to let cattle graze there).

The main source of income is in average derived from crop production. For most households, it is complemented with cattle husbandry, Non Timber Forest Product (NTFP) harvesting and sometimes part time jobs (Chin 2011). We reproduce here a list of major activities and their impacts on the tigers.

Table 1- Economic activities related to tiger conservation (WCS Russia n.d.; B. Li et al. 2009; WWF et al. 2010; Quach et al. 2010).

Activities	No harmful effect	Reduce habitat	Indirectly increases mortality of tigers	Directly increases mortality of tigers
Cattle husbandry		x	x	
Poaching of tiger preys			x	x
Poaching of tigers				x
Crop growing		x		
Frog breeding			x	
NTFP collection			x	
Forest exploitation	**x**			
Bee keeping	**x**			

Advocacy by scientists

Our thesis clearly advocates for the protection of biodiversity and, in our case study, for the conservation of Amur tigers. It also offers to *environmental strategic actors* advice and tools to advocate for the environment. Is such a posture justified for scientists ? Some consider science as a neutral discipline that should not interfere with society's choices (Lackey 2007). Other disagree and believe scientists have no choice but to advocate and may even have a responsibility to defend their values and the entities that are not taken into account by society at large (Chan 2008; Lach et al. 2003; Latour 1999).

Several powerful reasons justify advocacy by scientists:

1. Humans **are biased** by our own emotions and values, our preferences and experiences and it influences what we choose to study, the way we analyse results and "*to what extent we advocate particular policies or actions.*" (Noss 2007). Rather than hide those biases, scientists would be better off acknowledging them and advocating explicitly.
2. **Science is a social construction based on values** and thus rejecting advocacy because it is value laden does not make sense.
3. **(1) Policy makers may not sufficiently understand science** to make a rational choice and **(2) they may not be altruistic and honest** and thus may not behave in the best interest of the public. The best policy choice must therefore be clearly advocated for by scientists, in regard to their knowledge and studies.
4. **The intrinsic values of non-human beings** and the fact that they cannot speak for themselves so conservation biologists have to advocate for their protection. Actually, scientists must advocate for all entities that society as a whole does not recognize as part of its preoccupations (such as climate change which was all but ignored some years ago). These entities cannot speak for themselves as society ignores even their existence (Latour 1999).
5. **Scientists do not stand above the fray**: scientists and other stakeholders influence each other (for instance through funding) and the research results are not equally useful to all stakeholders. It is thus more productive to acknowledge one's bias than to pretend to be objective. Such a posture can yield satisfying results only if all stakeholders are represented by research teams, and their methodologies and results are discussed in a pluralistic debate (Mermet 2011).

Dangerous pitfalls stand between science and advocacy. Scientists must pay careful attention to them to avoid losing their credibility and producing dubious results. Chan (2008) identified the main pitfalls to avoid. **First**, researchers must obviously steer away from **biased science**, especially by abiding by the scientific process of documenting methods and assumptions and subjecting them to peer review. **Second**, **facts and values** must not be mixed; facts alone cannot determine which policies should be adopted because policy choice involves trade-offs between different values and it remains out of the scope of science. However, scientists can advocate for values they believe in as long as they indicate they express their personal opinions and do not abuse the public goodwill for science. Scientists are not superior to other citizen in the democratic exercise regarding trade-offs between values. **Third**, **dogmatism** must be avoided. That is to say one should not hold values as *protected values* that cannot be traded off with other values. **Finally**, advocates are required to be clear about their interests and values, otherwise the general public will imagine they pursue **hidden agenda**. Falling into these four pitfalls may yield short-term benefits for a given cause but they are both inappropriate and damaging in the long-term because they discredit scientists.

Cattle husbandry

Two main forms of husbandry can be distinguished: **traditional cattle husbandry** and **stall feeding**. The former benefits from collective (village owned) and State pastures located mostly inside the forests in areas cleared of trees. Cattle spend 7.5 months of a year inside these pastures at no cost to the farmer. Ungulates inhabiting the forests may suffer from diffuse competition with cattle grazing in the forests and above all, they are **disturbed by human presence** as farmers sporadically check their cattle in the forest (Prins 2000). This results in reduced ungulate population size and as a consequence the number of prey available for tigers decreases. Therefore cattle husbandry is considered *incompatible* with the *reference objective*. This system also implies that farmers only have to feed their cattle in winter, for 4.5 months of the year and they usually provide cattle with feed transformed from their own crops (soya bean, corn flour and corn straw). Microeconomic data collected revealed that transformation costs (e.g. from soya to soya bean) are extremely low, whereas **the opportunity costs of not selling crops are significant** and constitutes the bulk of the total costs for the household as a whole: **they tip the profit into loss**. In other words, although farmers' expense are extremely limited (which means they could imagine cattle husbandry earn them some money), in reality, they would be better off if they did not raise cattle as they would be able to sell the soya and the corn that they currently provide to their cattle in winter. Selling corn and soya would earn them more money than cattle husbandry currently does.

Compensation awarded by the government to farmers when they suffer a loss of livestock from tigers does not **on average** present a notable effect on average household profit. The explanation of this negligible effect lies in the low average rate of loss caused by tigers: only 0.2% (ie 2 out of 1000 heads of cattle are killed by tigers every year [B. Li et al. 2009]). The rate of attacks varies in Hunchun and some areas may suffer from higher rates. Our calculations reveal that compensation can bring profit back to zero if losses represent 5% of the herd every year. Compensation may also psychologically support farmers who suffered from a loss.

Our analysis unveiled a non-intuitive result: **public policies' main support to husbandry is not monetary but non-monetary** i.e. it does not consist of money awarded to or taxed from farmers. Instead it consists of provisioning services (Millennium Ecosystem Assessment 2005) provided by the forest pastures to farmers for free. The fodder provided to cattle during summer avoids hefty feed costs to farmers. In the absence of these forest pastures, farmers would have to provide feed to their cattle during almost twelve months of the year (very few, if any, pastures are available outside the forests). When these pastures are State owned and especially when they are located in the core zone of the Reserve, they are akin to *harmful subsidies* that increase environmental damages compared to a situation without compensation. The *harmful subsidy* literature usually limits its scope to monetary incentives(Bagnoli 2003, Fortuna 2011, Barde & Honkatukia 2004) but our work demonstrates non-monetary incentives can also represent significant stimulus to conduct activities that threaten biodiversity. Non-monetary incentives such as forest provisioning services can be modelled as *harmful subsidies* in microeconomic terms and the government can also exert control on them (at least when it owns the forests as is partly the case in the Hunchun Nature Reserve).

Interestingly, we note here a **conflict between one ecosystem service and a part of the biodiversity**: ungulates and tigers. The conservation of an ecoservice valuable for farmers, namely fodder-provisioning service from forest pastures, is in effect incompatible with the *reference objective* of increasing tiger populations[2]. This point deserves attention because it could mean that by assessing the value of ecosystem services and adapting management decisions accordingly (i.e. trying to maximise ecosystem services), decision-makers may actually jeopardize either other ecosystem services of less value or the biodiversity that presents a value that can hardly be assessed. Examples of such biodiversity include extraordinary biodiversity, that is to say well known species whose value is recognized by society, such as the polar bear, elephant, and Amur tiger. Chevassus-au-Louis et al. (2009) recommend against conducting economic assessments of extraordinary biodiversity because such assessments are inappropriate and imprecise. Are such conflicts between ecosystem services and the conservation of biodiversity the rule or the exception ? It warrants further investigation, especially in the context of the study of the uses of economic valuations of biodiversity.

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[2] We could consider these forests actually provide a cultural service related to the tigers they host and in this perspective, the conflict would thus occur between two forest ecoservices.

To demonstrate the importance of free pastures, field microeconomic data collection was indispensable: it would not have been possible to extrapolate it through aggregated measures.

The method of linking ecological data with economic data, though not new, brings about very interesting strategic insights: cattle husbandry's incompatibility with the *reference objective* stems from the pastures inside the forests. It does not constitute a “negotiable” incompatibility. Meaning, husbandry cannot renounce to those pastures to become *compatible* because **(1)** very few or no pastures are available outside forests and **(2)** raising cattle without free pastures involve costs too hefty to be borne by farmers. As a consequence, all kinds of husbandry, stall feeding included, are *incompatible*[3] and should not be promoted. It is thus not possible to promote **ecological intensification**. In addition, we demonstrate that on average, compensation plays a minor economic role. The focus of environmental actors should shift to the prohibition of forest pastures or, even better, to other *incompatible* drivers. Reversing the tolerance of local authorities towards cattle may however prove very difficult because of the State level desire to specialize the region in cattle husbandry (Banshi’s People Government 2011).

A final question remains: why does cattle husbandry persist ? The answer lies in two explanations. **First**, farmers may consider the profits of their activities one by one (“do my purchases related to cattle husbandry earn me more money than my sales ?”) rather than by the total profit of their household. As a consequence, they may not realize that they would earn more money if they sold their corn and soya instead of providing it to their cattle. **Second** and more convincingly, cattle present other uses such as labor in the field when mechanical tractors cannot be employed. Cattle can also represent a way to save money: heads are bought during prosperous time and sold during difficult ones. Additionally, some households may suffer from lower rate of loss than what we assumed[4] and consequently earn more money and possibly even make a profit.

Utilizations of economic valuations of biodiversity (EVB)

As the logical continuation of the work conducted by Laurans, Mermet, et al. (2011) where they listed all potential uses of EVB (UEVB) and reasons to explain why there were only very few mentions of decisive uses in the environmental economic literature, we listed potentials UEVB and their users in Hunchun.

We then looked for these expected UEVB in the field: only one apparent and obvious use was discovered: a (partial) evaluation of the use value of Amur tigers for ecotourism and tiger-friendly products. This UEVB is planned and has not yet been delivered.

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[3] Actually, some exceptions exist: some small pastures can be found near rivers and the (limited in numbers) farmers who use them may not need forest pastures. In addition, an international firm called Tianyi (天一) owns the only large size pasture outside the forest in Hunchun area. It reportedly hosts hundreds of heads of cattle and such cattle husbandry is not incompatible with tiger restoration.

[4] We assumed 13% of heads of cattle owned by the household are lost every year. Please refer to the full thesis for details (Chap. 2, III. A.).

None of the EVB we spotted in the scientific literature (Bi-han & Ji-xun 2005; Wu et al. 2002; 王宗明 et al. 2004; Zhou et al. 2009) was used and their authors did not mention any expected use in their articles either.

Why were I unable to observe UEVB in Hunchun ? I lacked time and resources to meet most of the decision makers and acquire documents related to decisions. Consequently I may have missed some UEVB. I can however affirm **there is no evident and easily accessible UEVB**, for the following **set** of reasons: **(1)** economic valuations need to be perfected to correct *inaccuracy* and *incompleteness* issues and **(2)** the decision context does not favour EVB: **(a)** decision-makers lack economic education, **(b)** regulatory frameworks are not conducive and **(c)** decisions sometimes need obscurity and ambiguity, they thus avoid the transparency (e.g. on the distributions of costs and benefits between agents) brought about by assessments. All these reasons play an important role. One additional explanation is that decisions are based on trade-offs between values and the economic value of biodiversity. Ecoservices represent only one of these values and cannot be **decisive** alone.

EVB also offers little operational value: it does not indicate which drivers threaten biodiversity (which is the role of ecology) or how these drivers can be changed. Nor does it provide indications on how to adjust economic instruments to protect biodiversity. For instance, the amount paid to households that benefit from Payments for Environmental Services (PES) are not based on the value of these services (indeed no assessment of their values are conducted [Landell-Mills & Porras 2002]) but on the opportunity costs households face to protect them. It is thus economic evaluation of the adversaries of biodiversity that provide data to adjust these instruments.

Use of economic valuations to design relevant and efficient economic incentives

Despite the unwillingness of some agents (presumably *sector-based actors*) to use economic evaluations, some minority *strategic environmental actors* may want to conduct an economic assessment of economic activities that threaten biodiversity. Subsequently they may conduct their accountancy to reveal how efficient economic incentives can be designed to make these economic activities which threaten biodiversity change. We later detail how to realize such accountancy.

However it is first necessary to determine which activities to target with these incentives to be *relevant*. If the wrong activities are targeted, then the results can be either a lack of conservation outcome (if the intensification of the activity targeted does not influence *incompatible* drivers) or worse the promotion of an *incompatible* driver. For instance, the public money spent to stimulate stall feeding potentially raises the number of cattle present in the forests and the frequency of human disturbances in these same places. It therefore worsens the situation of Amur tigers and indeed promotes an *incompatible* driver. Ecology, and not economics, establishes causality links between human activities and impacts on the ecological conditions that need to be maintained to reach the *reference objective*. Once it is clear which activities are *incompatible*, they can be directly or indirectly targeted.

To be *efficient*, the economic incentive must meet three criteria:

1. It must act on inputs (workforce, assets such as tractors, etc.) needed by the target incompatible activity. These inputs must be influenced or consumed when the target activity needs them[5]. For instance, providing funding to villagers so that they buy bee boxes and engage in bee keeping

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[5] In our thesis, we insisted on the temporal aspect but neglected the spatial aspect although it also represents a key element: incentives must act at the places where they are required.

represents an inefficient incentive because the input needs of bee keeping do not overlap with incompatible activities such as poaching or cattle husbandry. Poaching is indeed practised in winter when bee keepers are idle and vice-versa in summer. Cattle husbandry is not time-consuming in summer either and farmers can conduct both bee keeping and cattle husbandry at the same time.

2. The incentive must tip the economic balance in favour of a compatible activity. I.e. the profits of the compatible future activity must be superior to the current incompatible ones (in other words, the opportunity costs must be negative).
3. Its temporal structure of gains also needs to satisfy the target households. This last point can be illustrated by the comparison of stall feeding and traditional cattle husbandry. Both require farmers to pay first while the cattle is growing and to earn a profit only after several years when the cattle is finally sold. But the distribution of these costs and gains differs. Stall feeding concentrates both costs and gains. It offers generous profits but requires significant upfront costs. In contrast, traditional husbandry is associated with a feeble or even negative profit but costs are all but non-existent (except the opportunity costs of feed but they do not translate into expense by farmers) before the sale of the cattle. Traditional husbandry thus spreads the costs and the profit on a longer period of time. In these conditions, some farmers may be willing to continue to raise cattle traditionally because they are not able or willing to advance the consequent sums needed in short periods by stall feeding (and incidentally to expose themselves to high risks of losing all their money if the stall-fed cattle suddenly die in a disease outbreak).

Analytical accountancy tools for research and strategic analysis

To unveil the **integrative** (creation of social value) and **distributive** (who gains, who loses) aspects of environmental issue, we believe **analytical accountancy (AA) represents an adapted instrument**. AA employs the usual measures of accountancy such as revenues, profits, amortization, etc. but it then organizes the accounts and creates new indicators to serve the analysis. AA is preferable to the commonly used cost-benefit analysis in dealing with environmental issues because the latter misses a critical aspect of these issues: the distribution of costs and benefits between economic agents (Mermet 2003). My development of some analytical tools is intended both for researchers and for decision-makers. These tools present the dual aims of not only helping the researcher to organize its accountancy data and shed light on what data are missing, but also to display data in a telling and quickly understandable way. They are best for decision-makers who seek to understand their leeways and which activities they should target. These tools may not be new but we adapted and extended them to fit the specific needs of the analysis of economic activities threatening biodiversity.

The first tool we developed consists of a drawing named the **dashboard of incitations**. Its principle is very simple: it places a specific economic agent, the household, at the centre of the analysis (which physically translates into a central position of the household on the drawing) and then lists all the economic incentives the household faces. Positive economic incentives are placed above the household and negative economic incentives below the household. Other factors influencing the agent's choices are represented: cultural and social factors on the left, and characteristics of the household and its environment in the centre (which also symbolize the agent itself). All the elements we described insofar are mainly useful to researchers. The interest of the dashboard for decision-makers stems from the difference between **alternative scenarios** it represents and the **aggregated indicators** drawn on the right of the dashboard. What are the prices and quantities a household faces and produces in the current situation (alternative 1), and in a hypothetical situation where taxes would be higher (alternative 2) ? A quick glimpse on the dashboard provides some answers. Colours are also used to distinguish between types of elements. We reproduce the principle of the dashboard below.

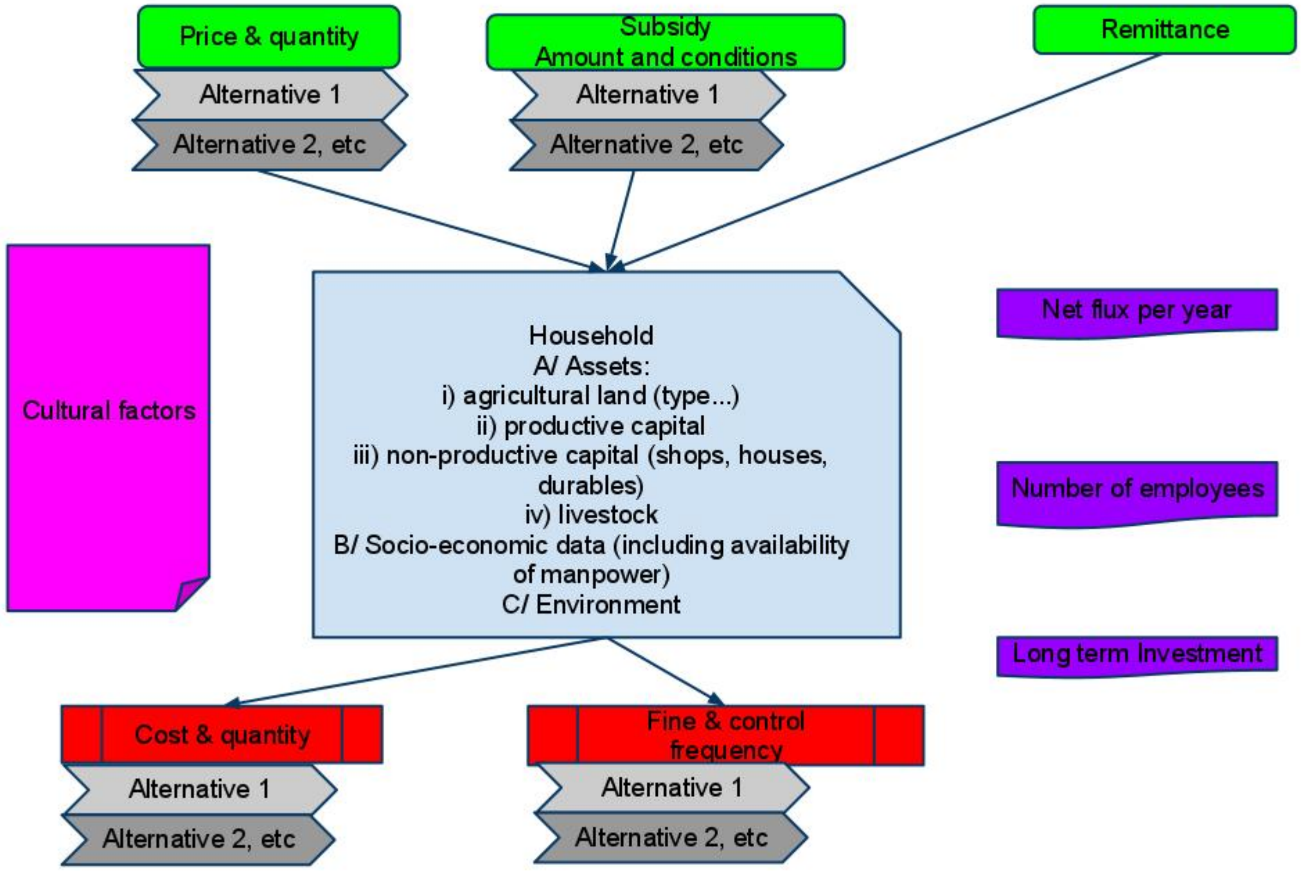

Figure 1 - Extension of the analytical accountancy: a dashboard to visualize data.

Then, following other environmental economic authors, we believe the notions of *reliance* and *extraction* are instrumental to both understand the relation of households with their environment and to design efficient policies to modify household behaviour in favour of the environment (Coomes et al. 2004; Takasaki et al. 2000). Unfortunately, quantifying the *extraction* of natural resources conducted by households in Hunchun was beyond our skillset and means. Our focus therefore was on the quantification of *reliance* (i.e. to what extent villagers depend on their different income sources). Graphically, it translates into arrows connecting the household (at the centre) and the sources (what produced the good sold or the direct value transfer). The width of the lines depends on the relative importance of the source. We reproduce our figure for Hunchun below.

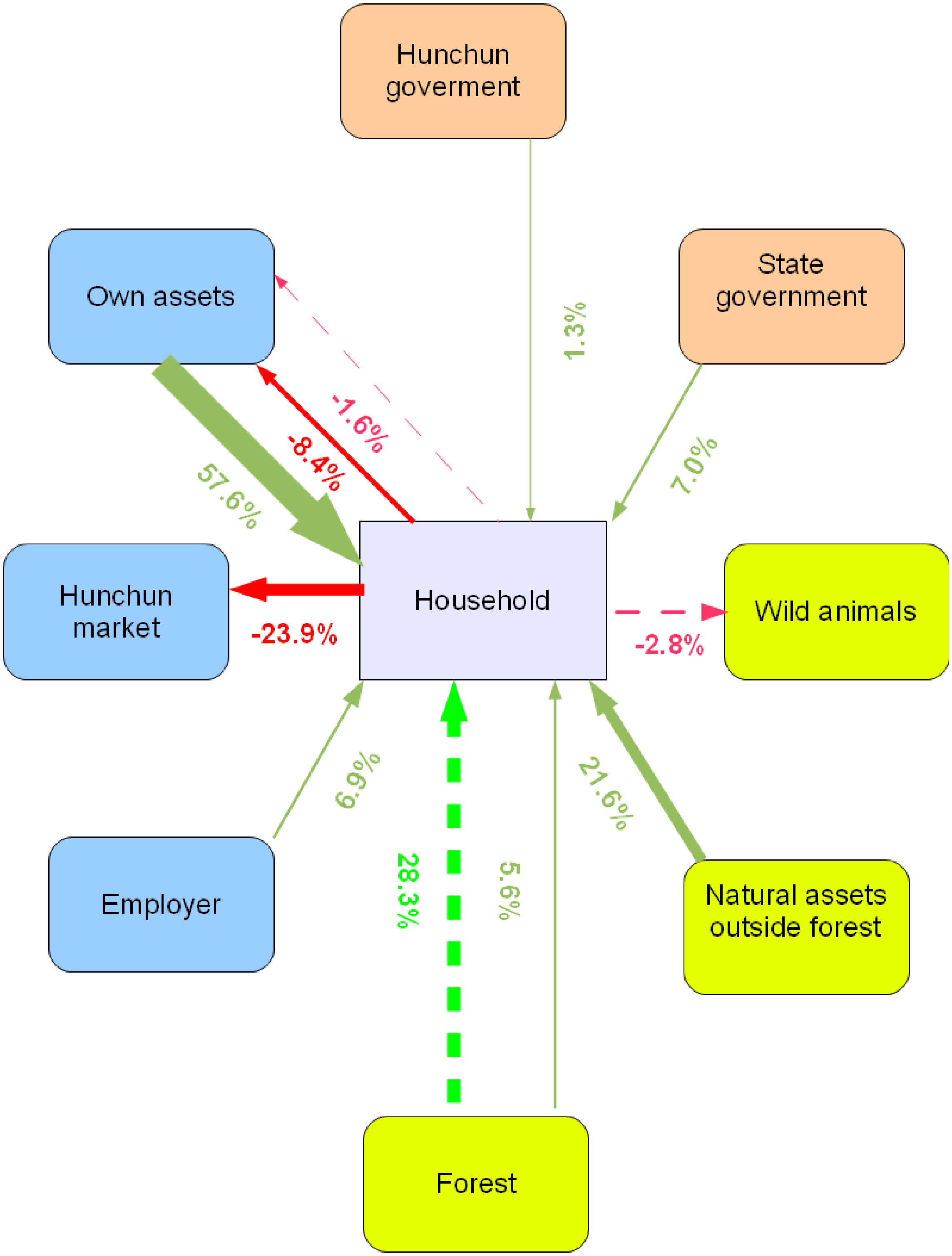

Figure 2 - Household's reliance on each source of income in Hunchun.

The last tool developed deals with **revenue formation**. We already stressed the inadequacy of an assessment that would only consider the profit and not its temporal structure. Our tool remains extremely rudimentary but captures this temporal structure by simply drawing the fluxes (monetary fluxes and the valuation of non-monetary fluxes) and the cumulated flux against time. Two alternative (such as traditional husbandry and stall feeding) can then be compared. A possible and obvious improvement would be to consider actual and not current values as we did (with the relevant discount rate).

Data required to complete findings

The paragraphs on scientists and advocacy underline how scientists must be rigorous and describe precisely the assumptions on which their work is based. Similarly, rigorous science involves disclosing the weakness of the analysis and the data that are missing to obtain more comprehensive results, and this becomes especially essential when one plans to advocate for a specific value. These last paragraphs aim at disclosing how data could have been better (and indirectly point out further research directions).

Some actors remained elusive and no interviews were conducted with them. None of the data about the poaching business was obtained from first-hand sources since poachers, middlemen and consumers remained invisible. Extrapolation from second-hand sources also guided our work about another sector, namely road and railway building, as we did not meet with any officials or companies involved with this driver. Hunchun is located near China’s border with Russia and North Korea and, despite reportedly becoming more relaxed, remains a difficult place to work for foreigners. Unsurprisingly, officials in charge of decisions related to biodiversity (creation of the reserve, design of compensation schemes) remain inaccessible to foreign researchers.

Our focus on microeconomic data of the households led us to collect precious data related to livestock husbandry. But details about fines for infringing the law could not be checked. Microeconomic data related to drivers other than livestock husbandry remain incomplete, especially for crop production and poaching.

Finally, our work was supposed to study the dynamics of whole sectors (e.g. how the relationship and power balance between wholesaler, middlemen and producers shape the driver) but difficulty of access to the main protagonists of the sectors of interest (cattle husbandry, road and railway building, frog farming, etc.) hindered our research and in most cases limited us to the study of producers.

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